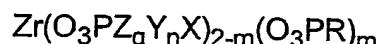


CLAIMS

What is claimed is:

1. A compound having the following structure:

5



wherein

10 X = a functional group selected from the group consisting of CO_2H , $\text{PO}(\text{OH})_2$, SO_3H , and $\text{SO}_2\text{NHSO}_2\text{W}$, wherein W = aryl of 6 to 10 carbon atoms or Y;

Y = perfluoro-linear, branched or cyclic alkylene group, wherein the alkylene is 1-20 carbon atoms, or a fluorinated group containing at least one substituent selected from the group consisting of oxygen, chlorine and bromine;

15 Z = alkylene of 1-12 carbon atoms, aryl of 6-10 carbon atoms, or a heterocyclic aryl group of 3-10 carbons atoms;

R = alkyl of 1-12 carbon atoms, aryl of 6-10 carbon atoms, substituted alkyl, or substituted aryl, wherein the substituent is selected from the group consisting of F, Cl, perfluoroalkyl, alkyl of 1-12 carbon atoms and aryl of 6-10 carbon atoms;

n = 0 or 1;

q = 0 or 1; and

25 m = 0 to 1.5; with the proviso that when n = 0, and q = 1, Z = at least one heterocyclic group having 3 to 10 carbon atoms, 1 to 5 nitrogen atoms and 0 to 4 oxygen atoms.

2. The compound of Claim 1 wherein Y = perfluoro-linear, branched or cyclic alkylene group, wherein the alkylene is selected from the group consisting of perfluoromethylene, perfluoroethylene and perfluoropropylene.

30 3. The compound of Claim 1 wherein Y is $\text{CF}_2\text{CF}_2\text{OCF}_2\text{CF}_2$ or $\text{CF}_2\text{CFCF}_3\text{OCF}_2\text{CF}_2$.

4. The compound of Claim 1 wherein Z = a heterocyclic aryl group comprising 3 to 8 carbon atoms, 1 to 5 nitrogen atoms, and 0 to 4 oxygen atoms.

35 5. The compound of Claim 4 wherein the heterocyclic aryl group comprises 3 to 8 carbon atoms, 2 to 3 nitrogen atoms, and 0 to 2 oxygen atoms.

6. The compound of Claim 4 wherein Z is selected from the group consisting of benzimidazole, imidazole, pyrazole, triazole, thiazole, and oxadiazole.

5 7. The compound of Claim 1 wherein R is selected from the group consisting of methyl, ethyl, propyl, butyl and phenyl.

8. The compound of Claim 1 selected from the group consisting of Zr(HO₂CCF₂CH₂CH₂CH₂PO₃)₂, Zr(H₂O₃PCF₂CH₂CH₂CH₂PO₃)₂, Zr(HO₃SCF₂CF₂OCF₂CF₂CH₂CH₂CH₂PO₃)₂, Zirconium (2-benzimidazolyl-2-ethylphosphonate), Zirconium (2-imidazolyl-2-ethylphosphonate), Zirconium (2-pyrazolyl-2-ethylphosphonate), and Zirconium (2-oxadiazolyl-2-ethylphosphonate).

10 9. A functionalized phosphonic acid having the following structure:



15 wherein

X = a functional group selected from the group consisting of CO₂H, PO(OH)₂, SO₃H, and SO₂NHSO₂W, wherein W = aryl of 6 to 10 carbon atoms or Y;

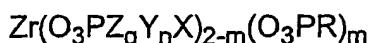
20 Y = perfluoro-linear, branched or cyclic alkylene group, wherein the alkylene is 1-20 carbon atoms, or a fluorinated group containing at least one substituent selected from the group consisting of oxygen, chlorine and bromine;

Z = alkylene of 1-12 carbon atoms, aryl of 6-10 carbon atoms, or a heterocyclic aryl group of 3-10 carbons atoms;

25 n = 0 or 1; and

q = 0 or 1; with the proviso that when n = 0, and q = 1, Z = at least one heterocyclic group having 3 to 10 carbon atoms, 1 to 5 nitrogen atoms and 0 to 4 oxygen atoms.

30 10. A solid electrolyte membrane comprising a compound having the following structure:



wherein

35 X = a functional group selected from the group consisting of CO₂H, PO(OH)₂, SO₃H, and SO₂NHSO₂W, wherein W = aryl of 6 to 10 carbon atoms or Y;

Y = perfluoro-linear, branched or cyclic alkylene group, wherein the alkylene is 1-20 carbon atoms, or a fluorinated group containing at least one substituent selected from the group consisting of oxygen, chlorine and bromine;

5 Z = alkylene of 1-12 carbon atoms, aryl of 6-10 carbon atoms, or a heterocyclic aryl group of 3-10 carbons atoms;

R = alkyl of 1-12 carbon atoms, aryl of 6-10 carbon atoms, substituted alkyl, or substituted aryl, wherein the substituent is selected 10 from the group consisting of F, Cl, perfluoroalkyl, alkyl of 1-12 carbon atoms and aryl of 6-10 carbon atoms;

n = 0 or 1;

q = 0 or 1; and

15 m = 0 to 1.5; with the proviso that when n = 0, and q = 1, Z = at least one heterocyclic group having 3 to 10 carbon atoms, 1 to 5 nitrogen atoms and 0 to 4 oxygen atoms.

11. The solid electrolyte membrane of Claim 10 further comprising a porous support.

12. The solid electrolyte membrane of Claim 10 wherein Y = perfluoro-linear, branched or cyclic alkylene group, wherein the alkylene is 20 selected from the group consisting of perfluoromethylene, perfluoroethylene and perfluoropropylene.

13. The solid electrolyte membrane of Claim 10 wherein Y is $\text{CF}_2\text{CF}_2\text{OCF}_2\text{CF}_2$ or $\text{CF}_2\text{CFCF}_3\text{OCF}_2\text{CF}_2$.

14. The solid electrolyte membrane of Claim 10 wherein Z = a 25 heterocyclic aryl group comprising 3 to 8 carbon atoms, 1 to 5 nitrogen atoms, and 0 to 4 oxygen atoms.

15. The solid electrolyte membrane of Claim 14 wherein the heterocyclic aryl group comprises 3 to 8 carbon atoms, 2 to 3 nitrogen atoms, and 0 to 2 oxygen atoms.

30 16. The solid electrolyte membrane of Claim 14 wherein Z is selected from the group consisting of benzimidazole, imidazole, pyrazole, triazole, thiazole, and oxadiazole.

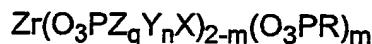
17. The solid electrolyte membrane of Claim 10 wherein R is 35 selected from the group consisting of methyl, ethyl, propyl, butyl and phenyl.

18. The solid electrolyte membrane of Claim 10 wherein the compound is selected from the group consisting of $\text{Zr}(\text{HO}_2\text{CCF}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{PO}_3)_2$, $\text{Zr}(\text{H}_2\text{O}_3\text{PCF}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{PO}_3)_2$,

$\text{Zr}(\text{HO}_3\text{SCF}_2\text{CF}_2\text{OCF}_2\text{CF}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{PO}_3)_2$, Zirconium (2-benzimidazolyl-2-ethylphosphonate), Zirconium (2-imidazolyl-2-ethylphosphonate), Zirconium (2-pyrazolyl-2-ethylphosphonate), and Zirconium (2-oxadiazolyl-2-ethylphosphonate).

5 19. A catalyst coated membrane comprising a solid electrolyte membrane having a first surface and a second surface, an anode present on the first surface of the solid electrolyte membrane, and a cathode present on the second surface of the solid electrolyte membrane, wherein the solid electrolyte membrane comprises a compound having the

10 following structure:



wherein

15 X = a functional group selected from the group consisting of CO_2H , $\text{PO}(\text{OH})_2$, SO_3H , and $\text{SO}_2\text{NHSO}_2\text{W}$, wherein W = aryl of 6 to 10 carbon atoms or Y ;

20 Y = perfluoro-linear, branched or cyclic alkylene group, wherein the alkylene is 1-20 carbon atoms, or a fluorinated group containing at least one substituent selected from the group consisting of oxygen, chlorine and bromine;

25 Z = alkylene of 1-12 carbon atoms, aryl of 6-10 carbon atoms, or a heterocyclic aryl group of 3-10 carbons atoms;

20 R = alkyl of 1-12 carbon atoms, aryl of 6-10 carbon atoms, substituted alkyl, or substituted aryl, wherein the substituent is selected from the group consisting of F , Cl , perfluoroalkyl, alkyl of 1-12 carbon atoms and aryl of 6-10 carbon atoms;

30 $\text{n} = 0$ or 1 ;

25 $\text{q} = 0$ or 1 ; and

30 $\text{m} = 0$ to 1.5 ; with the proviso that when $\text{n} = 0$, and $\text{q} = 1$, $\text{Z} =$ at least one heterocyclic group having 3 to 10 carbon atoms, 1 to 5 nitrogen atoms and 0 to 4 oxygen atoms.

35 20. The catalyst coated membrane of Claim 19 wherein the solid electrolyte membrane further comprising a porous support.

35 21. The catalyst coated membrane of Claim 19 wherein $\text{Y} =$ perfluoro-linear, branched or cyclic alkylene group, wherein the alkylene is selected from the group consisting of perfluoromethylene, perfluoroethylene and perfluoropropylene.

22. The catalyst coated membrane of Claim 19 wherein Y is $\text{CF}_2\text{CF}_2\text{OCF}_2\text{CF}_2$ or $\text{CF}_2\text{CFCF}_3\text{OCF}_2\text{CF}_2$.

23. The catalyst coated membrane of Claim 19 wherein Z = a heterocyclic aryl group comprising 3 to 8 carbon atoms, 1 to 5 nitrogen atoms, and 0 to 4 oxygen atoms.

5 24. The catalyst coated membrane of Claim 23 wherein the heterocyclic aryl group comprises 3 to 8 carbon atoms, 2 to 3 nitrogen atoms, and 0 to 2 oxygen atoms.

10 25. The catalyst coated membrane of Claim 23 wherein Z is selected from the group consisting of benzimidazole, imidazole, pyrazole, triazole, thiazole, and oxadiazole.

26. The catalyst coated membrane of Claim 19 wherein R is selected from the group consisting of methyl, ethyl, propyl, butyl and phenyl.

15 27. The catalyst coated membrane of Claim 19 wherein the compound is selected from the group consisting of $\text{Zr}(\text{HO}_2\text{CCF}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{PO}_3)_2$, $\text{Zr}(\text{H}_2\text{O}_3\text{PCF}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{PO}_3)_2$, $\text{Zr}(\text{HO}_3\text{SCF}_2\text{CF}_2\text{OCF}_2\text{CF}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{PO}_3)_2$, Zirconium (2-benzimidazolyl-2-ethylphosphonate), Zirconium (2-imidazolyl-2-ethylphosphonate), Zirconium (2-pyrazolyl-2-ethylphosphonate), and Zirconium (2-oxadiazolyl-2-ethylphosphonate).

20 28. A fuel cell comprising a solid electrolyte membrane having a first surface and a second surface, wherein the solid electrolyte membrane comprises a compound having the following structure:

25
$$\text{Zr}(\text{O}_3\text{PZ}_q\text{Y}_n\text{X})_{2-m}(\text{O}_3\text{PR})_m$$

wherein

30 X = a functional group selected from the group consisting of CO_2H , $\text{PO}(\text{OH})_2$, SO_3H , and $\text{SO}_2\text{NHSO}_2\text{W}$, wherein W = aryl of 6 to 10 carbon atoms or Y;

35 Y = perfluoro-linear, branched or cyclic alkylene group, wherein the alkylene is 1-20 carbon atoms, or a fluorinated group containing at least one substituent selected from the group consisting of oxygen, chlorine and bromine;

Z = alkylene of 1-12 carbon atoms, aryl of 6-10 carbon atoms, or a heterocyclic aryl group of 3-10 carbons atoms;

R = alkyl of 1-12 carbon atoms, aryl of 6-10 carbon atoms, substituted alkyl, or substituted aryl, wherein the substituent is selected from the group consisting of F, Cl, perfluoroalkyl, alkyl of 1-12 carbon atoms and aryl of 6-10 carbon atoms;

5 n = 0 or 1;
q = 0 or 1; and
m = 0 to 1.5; with the proviso that when n = 0, and q = 1, Z = at least one heterocyclic group having 3 to 10 carbon atoms, 1 to 5 nitrogen atoms and 0 to 4 oxygen atoms.

10 29. The fuel cell of Claim 28 further comprising an anode and a cathode present on the first and second surfaces of the solid electrolyte membrane.

 30. The fuel cell of Claim 29 further comprising gas diffusion backings adjacent the anode and cathode.

15 31. The fuel cell of Claim 28 further comprising gas diffusion electrodes comprising a gas diffusion backing and an electrode present on the first and second surfaces of the solid polymer electrolyte membrane, wherein the electrode is adjacent the solid polymer electrolyte membrane.

 32. The fuel cell of Claim 29 further comprising a means for delivering fuel to the anode, a means for delivering oxygen to the cathode, a means for connecting the anode and cathode to an external electrical load, methanol in the liquid or gaseous state in contact with the anode, and oxygen in contact with the cathode.

20 33. The fuel cell of Claim 28 wherein the fuel is hydrogen.

 34. The fuel cell of Claim 28 wherein the fuel is an alcohol.

25 35. The fuel cell of Claim 34 wherein the fuel is methanol.